SERIAL NO. 11342.

INSTRUCTION MANUAL
FOR
SENSITIVE RF VOLTMETER
MODELS 91DA, 91DA-R, 91DA-S5, & 91DA-R-S5

(Serial Numbers above 9383)

BOONTON ELECTRONICS CORPORATION

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SECTION 1

INTRODUCTION

1.1 General

This instruction manual describes Sensitive RF Voltmeter Models 91DA, 91DA-R, 91DA-S5, and 91DA-R-S5 and contains information for their operation and maintenance. This manual only covers equipment with serial numbers above 9383. The information in this manual applies to all four models of the equipment unless otherwise specified.

1.2 Differences in Models

a. Models 91DA and 91DA-R. Both models are electrically identical. However, Model 91DA is housed in a conventional equipment cabinet, while Model 91DA-R is mounted on a standard 19" panel 5" high and is equipped with a dust cover 10" deep to permit rack installation. Model 91DA-R also is equipped with a duplicate input connector at the rear of the unit.

b. Models 91DA-S5 and 91DA-R-S5. Both models are electrically identical. Model 91DA-R-S5 is equipped for rack installation and provided with a duplicate input connector in the same manner described for Model 91DA-R, above. Both models also are electrically identical to Model 91DA except for the RANGE - FULL SCALE switch and meter scale which are calibrated in dBm (50 Ω) rather than dB.

c. Power Requirements. The ac power source requirements for Models 91DA, 91DA-R, 91DA-S5, and 91DA-R-S5 are either 115 volts or 230 volts (nominal) at either 50 or 60 cps. The power requirement of each equipment is specified on the identification plate at the rear of the unit, and the frequency and voltage tolerances are listed in paragraph 1.3 of this manual. The specified power requirement and tolerances should be strictly observed to avoid equipment damage or serious measurement error.

d. Modifications in 50 cps Models. In all 50 cps models, some component part values differ from the values of corresponding parts in 60 cps models. Figure 6 illustrates the circuits modified in 50 cps models, and the added or substituted parts are identified in the Table of Replaceable Parts at the rear of this manual.

e. Modification in Models with Serial Numbers 9765 and Up.

Capacitor C110 (fig. 7) has been added to models having serial numbers 9765 and up to facilitate balancing out residual noise that may be introduced by chopper G101. The balance characteristic of models with serial numbers below 9765 may be improved by connecting C110 as shown in Figure 7.

1.3 Specifications

Voltage range	0.001 V to 3 V; 8 ranges in 1-3-10 increments
Voltage sensitivity	300 μV
Power sensitivity	0.0018 μW
Frequency range	20 Kc/s to 1200 Mc/s
dB range (91DA & 91DA-R)	81 dB (70 dB in 10 dB increments and 11 dB on meter scale)
dBm range (91DA-S5 and 91DA-R-S5)	-58 dBm to +23 dBm (-50 dBm to +20 dBm in 10 dBm increments and -8 dBm to +3 dBm on meter scale)
Accuracy (full scale):	
150 Kc/s to 100 Mc/s	±2% (±4% on 0.001 V range)
50 Kc/s to 150 Kc/s	±5%
100 Mc/s to 400 Mc/s	±5%
20 Kc/s to 50 Kc/s	±10%
400 Mc/s to 1.2 Gc/s	±10%
Input impedance	See Figure 1
DC output	At least 1 volt, linear, into a 1 KΩ load for FSD on any range.
Tube complement	2 - 12AX7 special (BEC 525,001) 1 - 7199 1 - 12AT7 1 - 6X4 1 - OA2
Power requirements:	
Voltage	115 V ac (nominal) ±10 V ac, or 230 V ac (nominal) ±20 V ac
Frequency	60 cps ±2 cps, or 50 cps ±2 cps
Power consumption	45 watts
Accessories supplied	RF Probe 91-12 (20 Kc/s to 1.2 Gc/s) Probe Tip 91-13B (20 Kc/s to 250 Mc/s)
Available accessories (not supplied)	91-6C Unterminated BNC Adapter 91-7C 100:1 Voltage Divider (50 Kc/s to 700 Mc/s) 91-8B 50Ω BNC Adapter 91-14A Type N Tee-Adapter* 91-15A Type N 50Ω Termination* 91-4C RF Probe (1 Kc/s to 250 Mc/s)

*For measurements within specified accuracy beyond 250 Mc/s (approx).

SECTION II

GENERAL DESCRIPTION

The 91DA RF Voltmeter is a sensitive instrument for the measurement of voltages of 300 microvolts to 3 volts spanning a wide frequency range of 20 kilocycles to 1200 megacycles. In addition to measuring voltage levels in a diversity of rf circuits, the instrument has application for many associated tests. Such measurements include: the frequency response of both active and passive networks, i.e., amplifiers and filters; VSWR and return loss on transmission lines and attendant systems; attenuation and insertion loss of rf attenuators; and high frequency parameters of transistors. With true rms response below 0.03 volt (up to 3 volts with the 91-7C, 100:1 Divider), harmonic distortion of rf waveforms and wide band noise can also be measured.

The instrument is also useful as an rf null detector for bridge measurements and analogous techniques.

The Model 91DA is supplied with RF Probe and removable Probe Tip with grounding clip lead.

The probe tip and companion ground clip are useful for direct measurements to approximately 100 megacycles. Above 100 megacycles the probe may be used directly without the tip but connecting leads must be extremely short to avoid resonant effects. In the special case where it is possible to connect the probe directly to the voltage source, the specified tolerance is maintained to at least 1200 megacycles. The impracticability of such a connection, however, precludes our assuring the accuracy of the 91DA RF Voltmeter above 250 megacycles without the use of the 91-14A Type N Tee Adapter and the 91-15A 50 ohm Termination.

The 91-12 probe with its full-wave crystal detecting circuit produces a true rms response without turnover or harmonic errors for all voltage levels below 0.03 volt, gradually changing to peak-to-peak reading (calibrated in rms) at the higher levels. The probe with the probe tip has a shunt capacitance of approximately 2.5 pF at levels of 0.5 volt or higher, increasing slightly at levels of 0.1 volt or less. The shunt resistance component is also a variable factor, depending on the voltage and frequency. (See Figure 1.)

The use of the 91-7C 100:1 Voltage Divider extends the voltage range to 300 volts (from 50 Kc/s to 700 Mc/s) and provides a true rms response up to 3.0 volts.

SECTION 111

OPERATION

3.1 General

This section should be read before using the instrument. It contains information necessary for proper operation of the 91DA RF Voltmeter.

3.2 Controls and Connectors

a. ON - This switch energizes the power transformer when the a-c cord and plug are connected to the proper power source as indicated on the serial number nameplate.

b. RANGE - FULL SCALE - VOLTS/DB - This range switch adjusts the amplifier gain, and/or the input attenuator, as well as the proper linearizing network for the selected voltage range.

c. PRESS TO BALANCE - This control introduces a small d-c voltage into the probe circuit to balance out minute thermal voltages that develop in low level d-c circuits. When the control is pushed toward the instrument panel, the meter circuit is altered to permit an upscale reading of the residual noise. The control should then be adjusted for minimum meter reading. The control knob must be released without turning.

d. OUTPUT TERMINALS - Two posts marked (+) and (-) are provided for external instrumentation. The voltage available from these terminals is a linear function of the input voltage and should be at least 1.0 volt for a full scale meter reading. The output impedance is low and nominally less than 600 ohms.

e. OUTPUT ZERO - This control provides a zero adjustment for the d-c voltage at the output terminals prior to applying r-f voltage to the probe.

f. PROBE - The probe cable connects to the instrument through this jack. It is imperative that the knurled ferrule nut of the probe cable connector be tightened.

3.3 Initial Procedure

a. Before the 91DA is turned on, the meter pointer should be examined to see that it rests on the zero reference line. If necessary, an adjustment may be made with the mechanical zero set on the meter.

b. Turn the instrument on and allow a warm-up period of 15 minutes. To assure maximum accuracy, a warm-up of 1 hour is recommended.

c. Connect the probe to the jack marked PROBE. Connect any of the coaxial adapters to the probe. Do not use the probe tip for this particular test.

d. Turn the RANGE-FULL SCALE switch to the 0.001 volt position and adjust the PRESS TO BALANCE control for a minimum reading. The knob for this control should be pushed toward the panel before an adjustment is made. See Section 3.2c.

3.4 Low Frequency Measurements

Frequencies within the range of 20 kilocycles to about 10 megacycles may be considered low frequencies for 91DA RF Voltmeter applications. Any of the adapters supplied with the instrument may be used in this spectrum. (Exception: the 91-7C 100:1 Voltage Divider has a low frequency limit of 50 kilocycles.)

In general, the high impedance probe may be used with a ground lead of 3 to 6 inches without introducing measuring errors. In the presence of strong fields, however, it is recommended that, where possible, the 91-6C Unterminated BNC Adapter be used.

For measurements at lower frequencies the Model 91-4C Probe is available. It operates over a frequency range from 1 Kc/s to 250 Mc/s. Important Note: After installing the Model 91-4C Probe, the RF Voltmeter must be checked for accuracy of calibration, and recalibrated if required (see paragraphs 5.5.3 and 5.5.4)

3.5 High Frequency Measurements

In the frequency domain of 10 megacycles to 250 megacycles, it is permissible to use the probe tip and a conventional ground clip at the lower frequencies whereas measurements at the upper frequencies of this band require special techniques.

Above approximately 100 megacycles, the inductance of any conductor at the input of the probe (either the ground lead or center conductor) may cause an appreciable error in the indicated voltage owing to partial resonance of the lead inductance and input capacitance of the probe. Moreover, any impedance in the ground lead may develop an error voltage owing to circulating currents between instruments. The importance of low impedance connections at high frequencies cannot be overemphasized.

For high impedance measurements at frequencies above 100 megacycles the probe should be connected without leads directly to the voltage source. The input impedance of the probe will have negligible effect upon low impedance circuits, i.e., less than 200 to 300 ohms. An example of such a connection is shown in Figure 2.

High impedance circuits in the range of 50 to 200 megacycles usually take the form of a parallel resonant circuit. Connecting

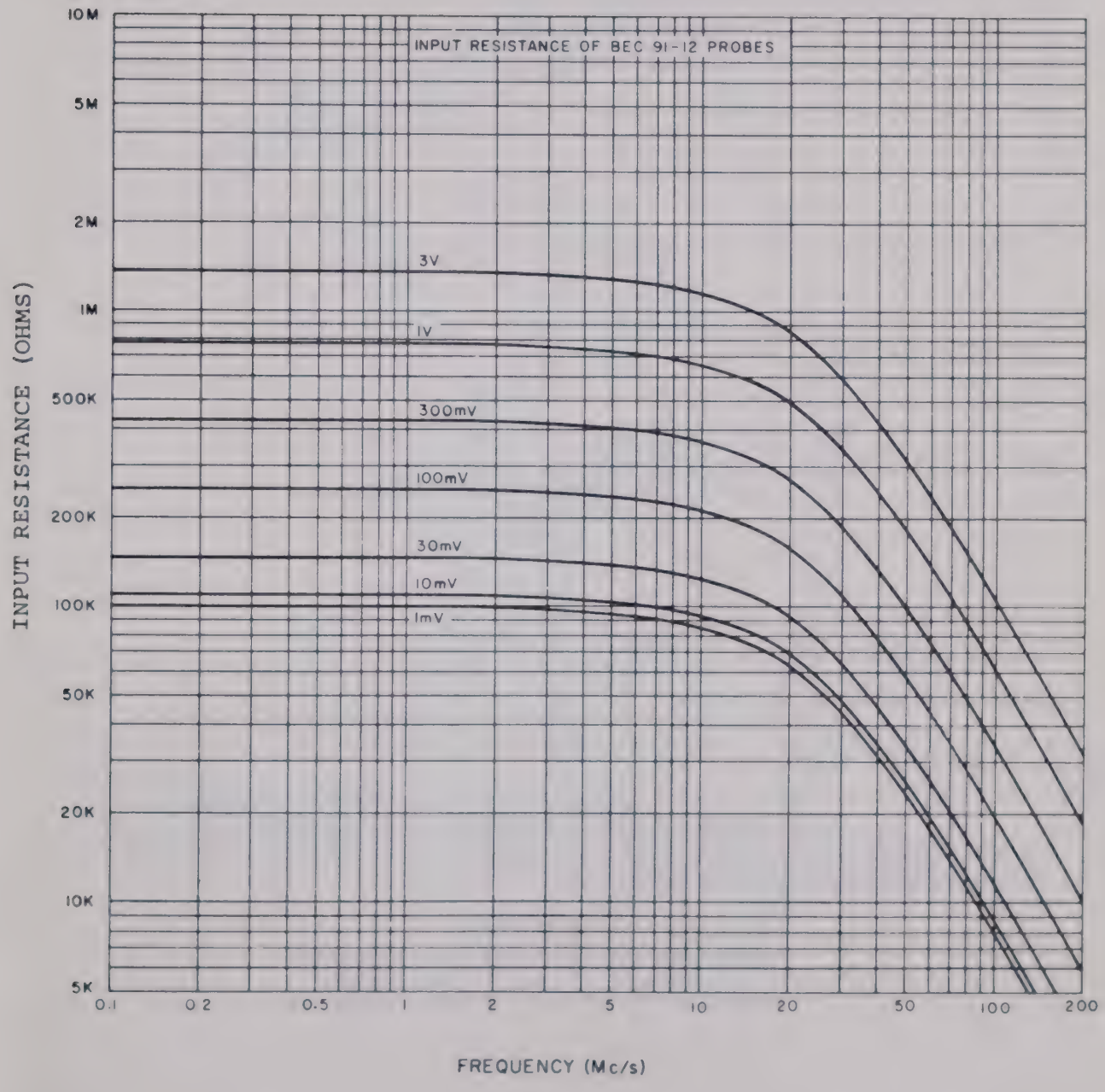
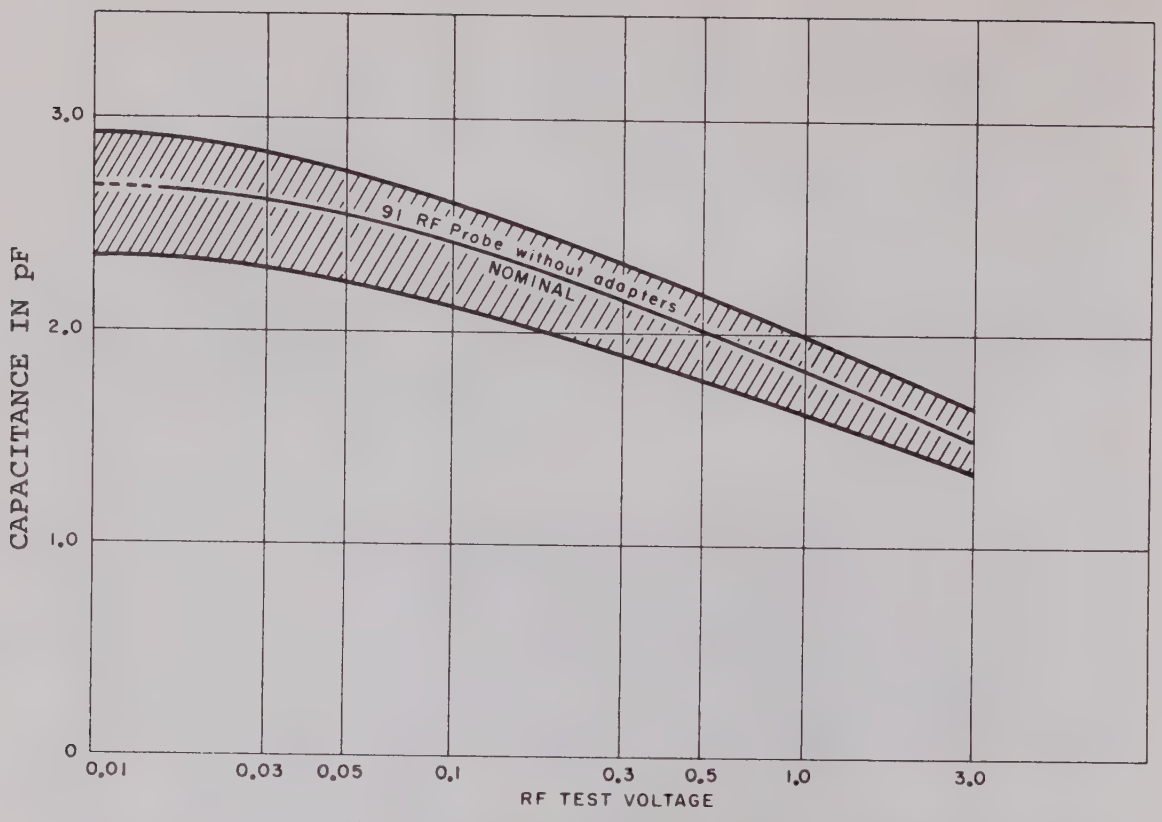
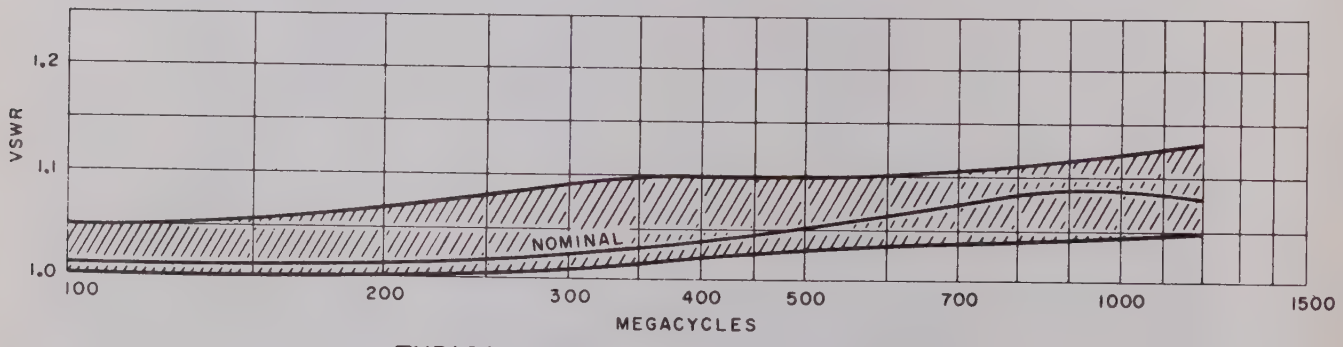

INPUT RESISTANCE OF BEC 91-12 PROBES
INPUT RESISTANCE (OHMS)
10M
5M
2M
1M
500K
200K
100K
50K
20K
10K
5K
3V
1V
300mV
100mV
30mV
10mV
1mV
0.1
0.2
0.5
1
2
5
10
20
50
100
200
FREQUENCY (Mc/s)

Figure 1 a



INPUT CAPACITANCE vs TEST LEVEL
(measured at 10 Mc)

Fig 1b



TYPICAL VSWR OF 91-12 RF PROBE
with 91-14 Type "N" Tee Adapter
terminated in a 91-15 50 Ohm Termination

Fig 1c

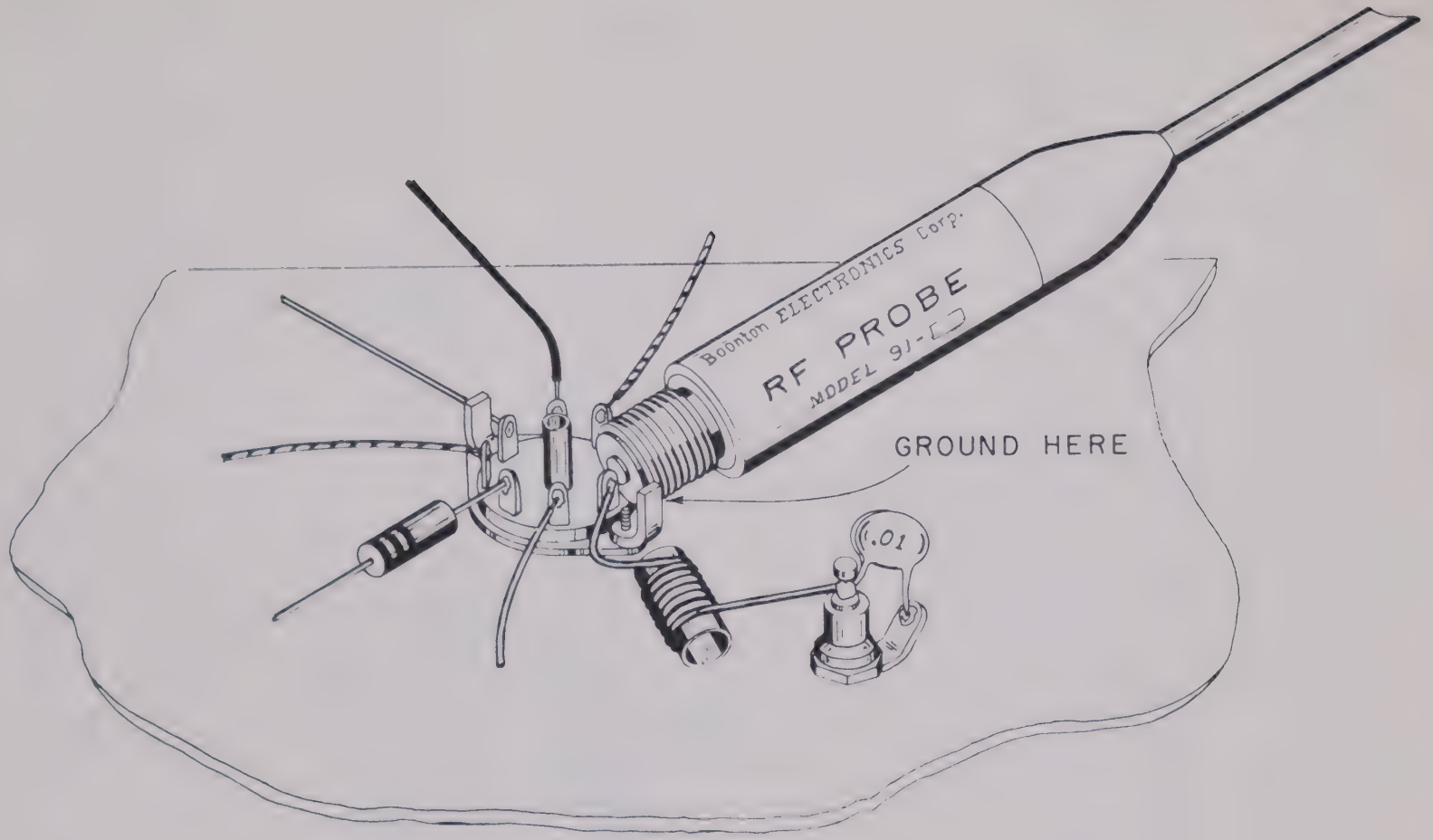


Fig. 2

the 91-12 probe to this type of circuit may have a twofold effect: (1) the input capacitance of the probe will detune the circuit, and (2) the resistive component of the input impedance will produce some loading across the circuit.

If the circuit to which the probe is connected is tuned by a variable capacitor, the correction for the first effect is to reduce the capacitance of the circuit by an amount equal to that added by the probe (2 to 3 pF). Correction for the loading effect is not as simple. The input resistance of the probe is to some extent a function of the voltage level applied to the probe. Figure 1 gives nominal values of input resistance vs. frequency for three voltage domains.

If the voltage to be measured exceeds 30 millivolts, the 91-7C 100:1 Voltage Divider is recommended for high impedance measurements at frequencies up to 700 megacycles. This adapter connects directly to the probe and may be introduced into the circuit in the same manner as suggested for the probe in Figure 2. The resistive loading presented by the 91-7B adapter is in the order of 100 megohms at 0.1 megacycles, decreasing to 0.1 megohm at 200 megacycles. Provided the input capacitance of about 2.5 pF exhibited by this adapter can be negated by retuning the circuit, the loading in most r-f circuits will be negligible.

An additional benefit which obtains with the use of the 100:1 Voltage Divider is an extension of the true rms operating region to 3.0 volts.

3.6 UHF Measurements

Voltage measurements are not recommended above 250 megacycles without the use of the 91-14A type N "Tee" Adapter and companion 91-15A 50 ohm Termination. Measurements should preferably be made in electrically short 50 ohm systems ($\ell < 0.1\ \lambda$). If an electrically long transmission line ($>0.25\ \lambda$) is interposed between the source and the 91-14A Tee Adapter, the return-loss of the source impedance should be moderately high (say, 20 dB, or more) to reduce the standing waves and attendant errors. The worst condition will exist with a poorly matched source impedance. Under this condition, the measured voltage at the terminus of a long line will be a function of the reflection coefficient, hence the VSWR, of the terminating resistor. In the case of the 91-14A and 91-15A, the maximum VSWR is 1.15 up to 1000 megacycles and less than 1.2 to 1200 megacycles.

It is important that the 91-14A Type N "Tee" adapter be used in the direction shown in Figure 3. For certain measurements it may be necessary to interpose a length of cable between the "Tee" Adapter and the Termination. If such a connection is made,

ADDENDUM FOR 91DA RF VOLTMETER INSTRUCTION BOOKS

The 91-14A Type N Tee Adapter is designed so that voltmeter responds to the voltage applied to the input of the tee adapter. Therefore, when the adapter is interposed in a line, or terminated with a device other than a simple resistive termination, it is necessary to account for the insertion loss of the tee adapter at frequencies above 500 Mc/s.

The correction in dB is given in Fig. 3a. The correction should be added to the meter reading (in dB) to obtain the output level of the tee adapter.

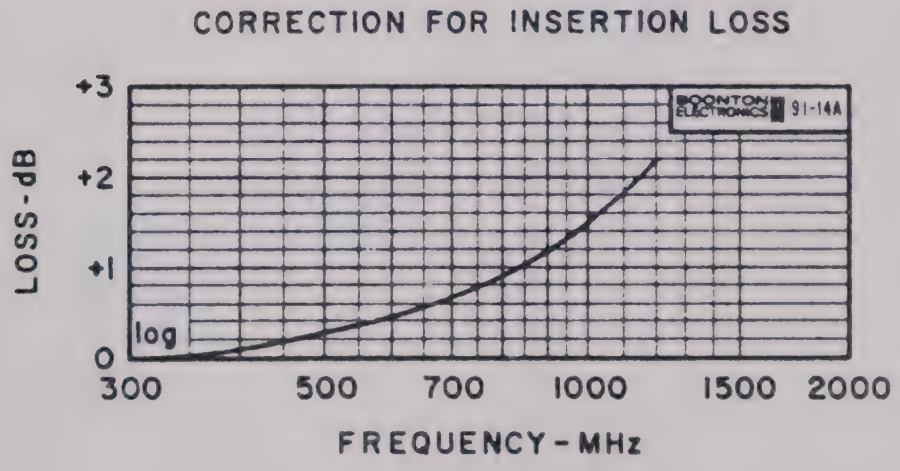


Fig. 3a

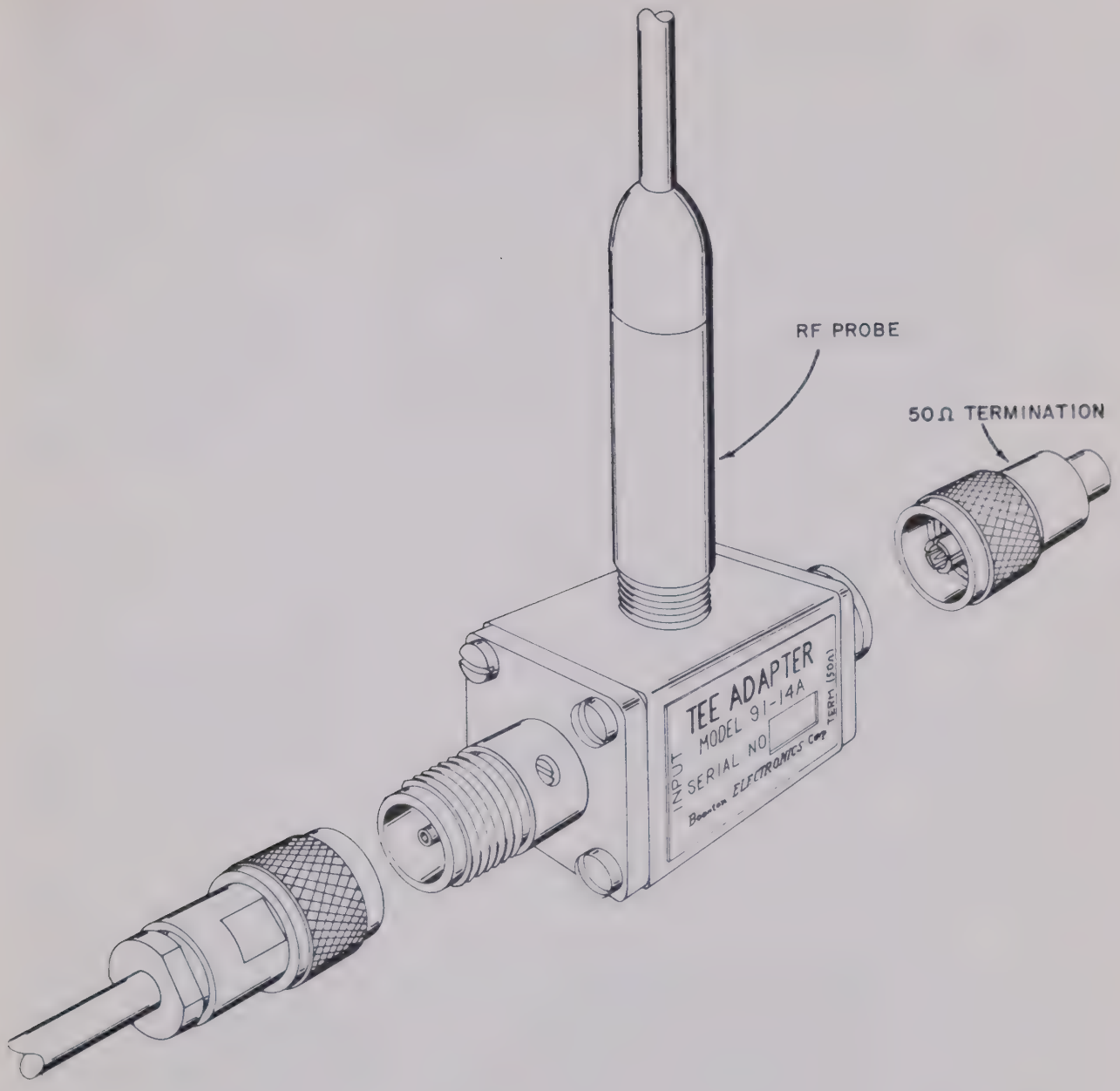

RF PROBE
50Ω TERMINATION
TEE ADAPTER
MODEL 91-14A
SERIAL NO
Boonton ELECTRONICS Corp
INPUT
TERM (50Ω)

Fig. 3

the cable selected should be of good quality with a characteristic impedance of 50 ohms.

Provision for disconnecting the 50 ohm termination permits the substitution of a test termination, or the interposition of the tee and probe at any convenient place in a transmission line system.

3.7 High Voltage Measurements

The 91-7C 100:1 Voltage Divider permits the measurement of voltage above 3 volts in the frequency range of 50 Kc/s to 700 Mc/s. At these frequencies, a maximum voltage of 300 volts may be measured with the divider. The d-c voltage rating of the input capacitor, however, is 1000 volts, and the crest voltage of combined d-c and r-f should, therefore, be kept below this value.

As previously mentioned, the 91-7C Adapter extends the true rms range of the RF Voltmeter from 30 millivolts (without the adapter) to 3.0 volts.

High voltage measurements up to 700 Mc/s can be made using the 100:1 Voltage Divider with either the high impedance probe tip, or by connecting the divider to the 91-14A Type Tee Adapter. The VSWR of the terminated tee adapter under this condition will not exceed 1.15 at frequencies up to 700 Mc/s.

3.8 Precautions

For long instrument life and optimum performance, a few precautions should be observed when using the 91DA RF Voltmeter.

3.8.1 Maximum Input Voltage-RF - To secure the many desirable properties of the special diodes used in the voltmeter probe, the peak reverse voltage rating cannot be made greater than about 30 volts with the present state of the art. This limits the maximum rms input level to approximately 9 volts; a margin of 3 to 1 above the maximum range of the instrument.

A simple precaution which will reduce the chance of diode burn-out is to use the 91-7C 100:1 Voltage Divider when working with r-f voltages above, say 100 millivolts, at frequencies from 50 Kc/s to 700 Mc/s. In addition, the advantages outlined in Section 3.7 also apply.

3.8.2 Maximum Input Voltage - DC - RF Voltages, superimposed on d-c potentials of up to 400 volts, may be measured without damaging the probe diodes. Higher d-c protection (to 1000V) may be obtained with the use of the 91-7C 100:1 Voltage Divider with an attendant reduction in sensitivity. Although protection of the probe for d-c voltages up to 400

volts is provided in the design, pulsing of the probe with higher d-c voltage may damage the diodes. Wherever possible, the circuit of Figure 4 should be used to remove the d-c component prior to measuring the r-f voltage.

3.8.3 High Intensity, Low Frequency Fields - The amplifier section of the 91DA RF Voltmeter has a maximum gain at 60 cps of approximately 120 dB. Although the instrument incorporates both magnetic and electrostatic shielding, the voltmeter cannot be expected to function properly on its more sensitive ranges in the proximity of strong 60 cycle fields.

One source of considerable interference, common in many laboratories, is the magnetic type of 60 cycle line voltage stabilizer. The 91DA RF Voltmeter should be operated at a suitable distance from such devices as well as other devices which generate high intensity fields.

It is suggested when using the RF Voltmeter on its most sensitive range in the proximity of any a-c line operated equipment, that the adjacent equipment be momentarily de-energized to note its effect upon the indication of the voltmeter.

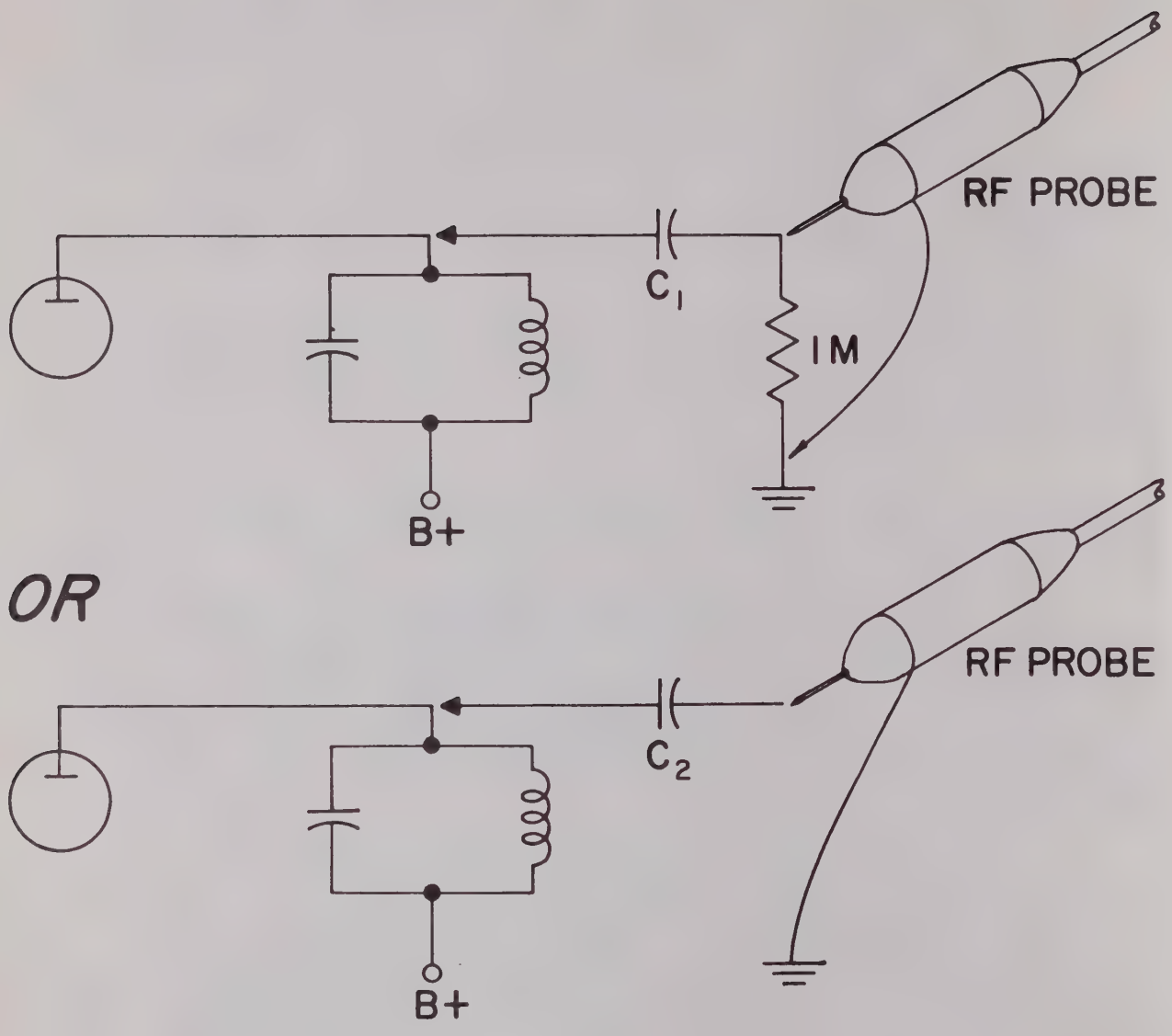
3.8.4 High Intensity, High Frequency Fields - The measurement of low level r-f voltages in the presence of high level, high frequency fields requires excellent shielding if gross errors are to be avoided. In particular, the use of the probe tip and companion ground clip is precluded. Moreover, the balancing operation required for the most sensitive range (1 millivolt) should be performed with the probe connected to the circuit which should be temporarily disabled.

It is likely that such measurements will require special fixtures and jigs to ensure accurate measurements.

3.8.5 Temperature Effects - The accuracy specifications for the Model 91DA apply over the temperature range from 65° F to 90° F. Outside of these limits operation of the equipment is possible but appreciable inaccuracies can be expected. However, no permanent change in probe characteristics will result from any reasonable high or low temperature exposure.

It should be noted that inaccuracies of measurement resulting from temperature effects may occur shortly after soldering to the probe tip, or measuring with the probe in the vicinity of heat sources such as resistors, heat sinks, vacuum tubes, etc.

When making low level measurements (below approximately 2 millivolts) it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and outside of the probe can generate a small thermal voltage that may add or subtract with the dc output generated by the detector diodes.



C_1 should be a sensible short circuit at the measuring frequency.

C_2 should be 100 pF or less.

METHODS FOR PROBE ISOLATION FOR HIGH DC VOLTAGES

Fig 4

SECTION IV

TECHNICAL DESCRIPTION

4.1 General

The 91DA RF Voltmeter employs a miniature, low capacitance probe which converts the r-f voltage to a proportional d-c potential. This d-c voltage is in turn converted to a 60 cycle a-c signal by a special low noise mechanical chopper. A selective amplifier follows the chopper and raises the 60 cycle level to a value sufficient for rectification, linearization, and metering. The DC Output Cathode Follower is also fed from this point. Additional circuitry is provided to spread the useful portion of the meter scale over a larger-than-normal percentage of the pointer range for greater readability.

4.2 Probe

The RF Probe contains a blocking capacitor and two high frequency diodes connected for full-wave rectification. Adequate by-passing and resistive isolation is included. The probe is connected to the voltmeter cabinet by means of a flexible low noise cable and connector.

Owing to the possibility of degradation of performance by replacing diodes in the probe without complete facilities for calibrating the instrument, components in the probe have not been shown on the schematic.

4.3 Chopper Modulator

The SPDT mechanical chopper has break-before-make contacts and operates from the 6.3 volt, 60 cycle winding of the power transformer. A low pass RC filter ahead of the chopper suppresses any 60 cycle voltage which may be introduced through the probe. After using the voltmeter on the 1 or 3 volt range, the capacitors in this filter will require 40 to 60 seconds to discharge sufficiently to permit operation on the 1 millivolt range.

A resistive attenuator appears between the output of the chopper and the input of the amplifier. The attenuator has five adjustments which are described in Section 5.

4.4 Amplifier

The amplifier in the 91DA raises the signal level from the chopper to a level adequate for converting the square-law response from the probe (for measured voltages of less than 30 millivolts) to a linear direct current for the meter. As the measured voltage increases, the extent of the conversion is reduced.

The BEC 525,001 (12AX7) Preamplifier is contained within the shielded box attached to the front subpanel. The box also houses the input attenuator and switching for feedback control in the preamplifier, as well as the chopper and its circuitry.

The preamplifier is followed by a second 12AX7 which drives the selective output amplifier.

The output stages consist of a combination pentode-triode tube (type 7199). The pentode operates as a normal amplifier and is coupled to the triode which functions principally as a cathode follower. Negative feedback is taken from the triode cathode in a conventional manner to the second cathode of V301. It is also applied through a frequency selective twin-tee network to the grid of the pentode section.

These circuits produce an output amplifier which is broadly tuned to 60∿ having approximately 18 dB of attenuation at 120∿. The output impedance of the cathode follower is sufficiently low to drive the rectifier circuit without appreciable distortion.

The combination of regulated d-c heater and plate voltage for the two 12AX7's, as well as negative feedback around all stages, makes the instrument calibration sensibly independent of line voltage changes from 105 to 125 volts.

4.5 Rectifier and Meter Circuit

The meter rectifier is a half-wave voltage doubler. The d-c voltage derived from this circuit is applied to a network of stabistors (voltage sensitive resistors) and adjustable resistors which are employed to convert the amplified non-linear response of the r-f probe to a linear current for the indicating meter.

4.6 DC Output Cathode Follower

This stage is provided to drive external recording equipment. The output voltage at the front panel terminals should be at least 1.0 volt (relative to full scale) when connected to a 1000 ohm load.

Although the d-c output voltage is a direct linear function of the r-f input voltage (as opposed to the expanded, but equally divided meter divisions), the d-c output is usable only when the meter is on some portion of its calibrated range.

4.7 Power Supply

A conventional full-wave rectifier, using a 6X4 vacuum tube, furnishes the necessary high voltage d-c potentials for the instrument. A portion of this voltage is regulated with an OA2 gas discharge tube for the plate voltage of the first and second amplifier tubes.

The heater voltage of these same stages is rectified and regulated using a silicon rectifier (full-wave bridge) and two germanium pnp power transistors.

Heater voltage for the output stage and the DC Cathode Follower is derived from the 6.3 volt transformer winding.

SECTION V

MAINTENANCE

5.1 Periodic Checking

The Model 91DA Voltmeter is designed to give long periods of service without maintenance when operated in accordance with the instructions in this book. It is recommended, however, that the instrument be checked periodically using reliable standards to ensure against errors resulting from deterioration of either the tubes or the chopper. To make these tests, it is necessary to have a signal source of 200 Kc/s to 500 Kc/s with less than 1% distortion at levels up to 3 volts across 50 ohms, a suitable attenuator to adjust this level between 300 microvolts and 3 volts, and a precision electronic voltmeter, such as the Hewlett Packard Model 400H, to monitor the signal source. The high frequency response of the 91DA may be checked with laboratory a-c to d-c transfer standards. The Ballantine Model 440 Micropotentiometer is recommended for this purpose.

5.2 Calibration Precautions

To check the calibration accuracy on an RF Voltmeter having the sensitivity and bandwidth of the Model 91DA, it is necessary to take precautions to avoid errors resulting from stray pick-up voltages. (See paragraphs 3.8.3. and 3.8.4.) A well shielded signal source must be used in conjunction with coaxial connections to both the Model 91DA and the standard reference meter. Even with such equipment it is sometimes possible for the reference meter to pick up stray RF signals and feed them to the probe. Check for this condition by disconnecting the standard meter and noting a change in level.

5.3 Calibration Check Procedure

Each range of the 91DA should be checked at a voltage representing 90% of full scale value. If these check points agree within ±1.5% of the standard, it is recommended that no adjustment be made. If the check points deviate by more than ±1.5% from the standard, the calibration adjustment procedure as outlined in paragraph 5.5 should be followed. If it is impossible to adjust the instrument to within 1% of the standard meter, it is recommended that a trouble shooting procedure be followed as outlined in paragraph 5.4.

5.4 Trouble Shooting Procedure

5.4.1 Case Removal - The instrument may be removed from its case after first removing the four screws located on each side of the case.

5.4.2 Tube Replacement - If the tube V101 should become weak or noisy, it should be replaced with BEC 525,001 or a commercial low noise 12AX7 which has low microphonism as well as low flicker noise. The Telefunken ECC83/12AX7 has consistently met these requirements. After replacing defective tubes, recheck the calibration as outlined in paragraph 5.3 and, if necessary, adjust the instrument as described in paragraph 5.5.

5.4.3 Chopper Replacement - Poor chopper performance usually is evidenced by an abnormally high meter indication on the 0.001 volt range for zero input voltage. However, be sure that meter performance is not being affected by high intensity fields (para. 3.8.3 and 3.8.4). If adjustment of the PRESS TO BAL control (para. 3.2c) does not lower the meter needle to zero or near zero, substitute a new chopper. If the substituted chopper does not correct the fault, check the calibration. If recalibration is required, allow at least one hour for warm-up and perform the calibration adjustment procedure (para. 5.5).

5.4.4 Voltage and Resistance Tests - After determining that the trouble cannot be cured by replacement of tubes or chopper, as described previously, it is advisable to make a systematic check of AC voltage, DC voltage and resistance at each socket pin. Table 2 shows the nominal AC and DC voltages to ground from each socket pin number. Table 3 shows the nominal resistance values expected for each point. Large or erratic deviations from the listed values of voltage or resistance will serve as a clue in tracking down a faulty component. Once the trouble has been found and corrected, the calibration must be rechecked and readjusted as outlined in paragraph 5.3 and paragraph 5.5.

5.5 Calibration Adjustment Procedure

Before making any calibration adjustment, it is essential to provide the necessary reference standards as described in paragraph 5.1 and take all precautions as outlined in paragraph 5.2. The calibration adjustment shall then be made as outlined in the following procedure.

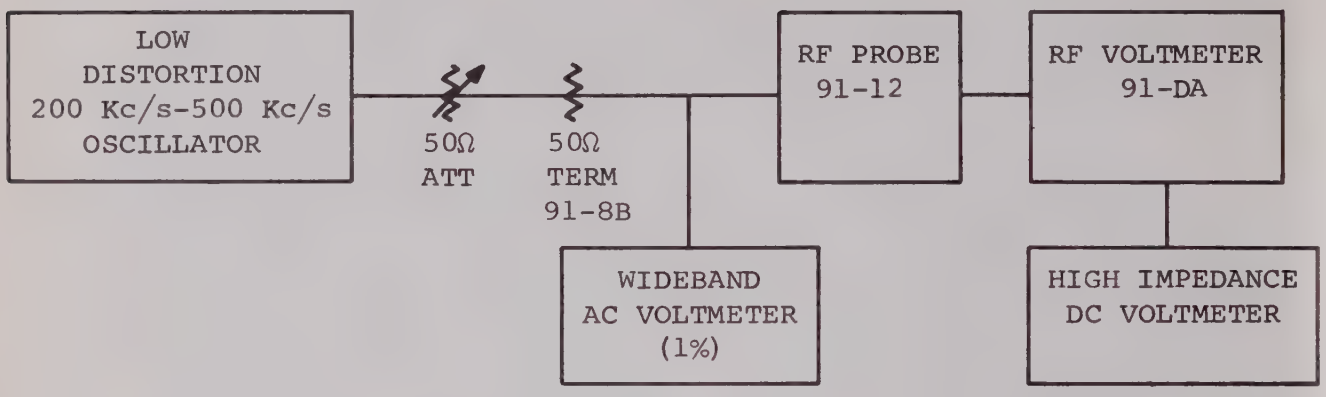
5.5.1 Equipment Required

a. A low distortion (< 1%) oscillator (200 Kc/s to 500 Kc/s) capable of generating 3 volts across 50 Ω.

b. A wideband a-c voltmeter with an accuracy of 1% or better, with a range of 300 microvolts to 3 volts.

c. A 50 Ω r-f attenuator with sufficient adjustment in conjunction with the oscillator level control to permit reduction of the level to 300 microvolts.

5.5.2 Calibration Set-Up - All connections on the following block diagram should be made with coaxial cable and connectors.



5.5.3 Preliminary Adjustment

a. Connect a high impedance dc voltmeter to the output of the meter rectifier circuit (junction of green lead and 120K resistor on top terminal board - see Figure 5). This point will be referred to as the dc test point.

b. With zero input to the 91DA, set the RANGE switch to 0.001 volt and adjust the PRESS TO BALANCE control for minimum indication on the meter.

c. Turn the RANGE switch to the 0.01 volt position and increase the input level to 0.01 volt.

d. Adjust 0.01 control (R143) at the top of preamp housing for a reading of -16 volts at the dc test point.

5.5.4 Calibration - Table I describes the procedure for calibrating each range of the 91DA, provided the steps of paragraph 5.5.3 have been followed. (Note: Access to linearity adjustments, i.e., controls 2 through 12, is possible by removing the Access Plate on the left side of the cabinet.)

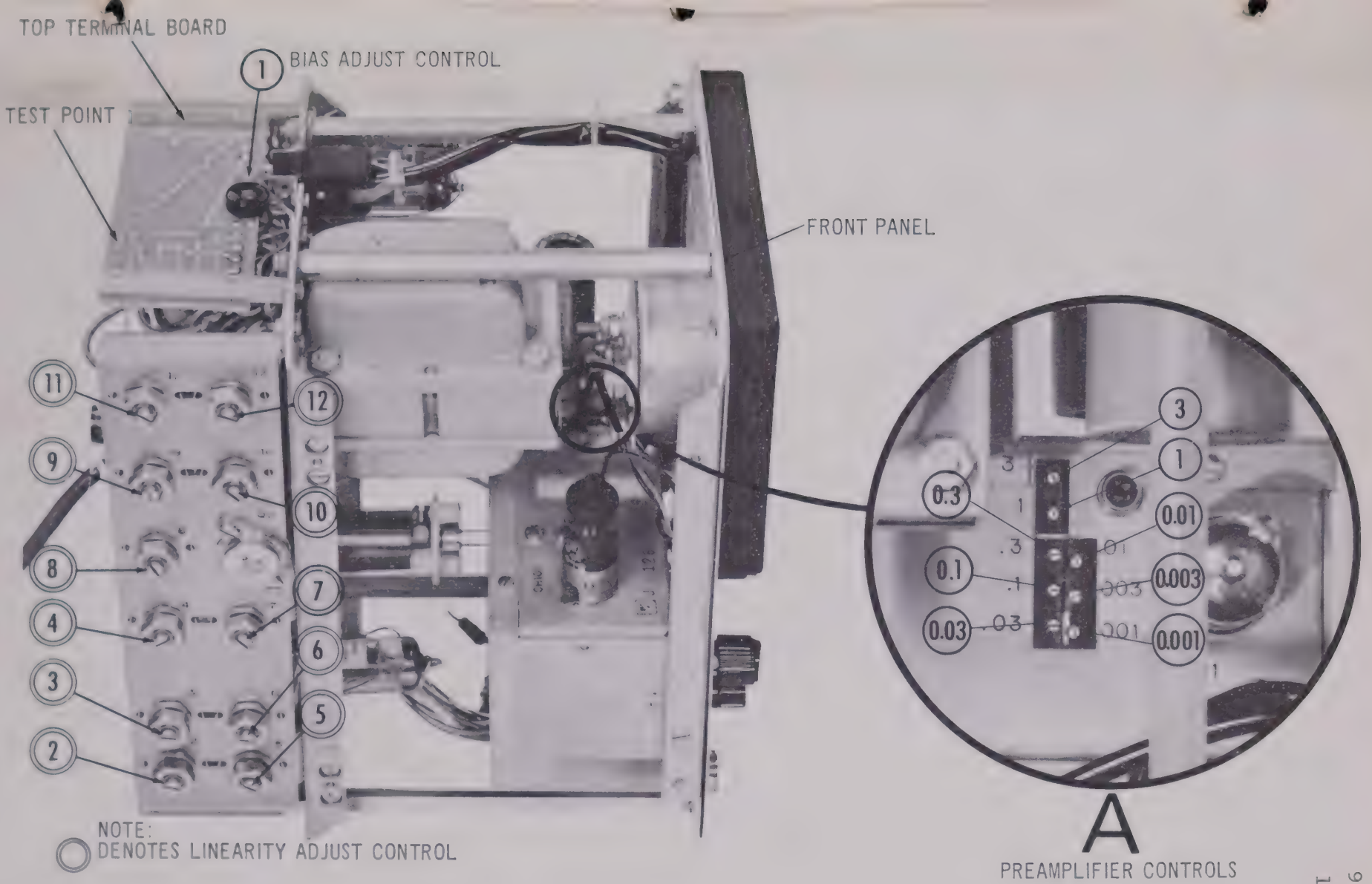


Fig. 5. Internal Controls and Test Point.

TABLE 1

CALIBRATION TABLE

STEP	RANGE SETTING	APPLIED VOLTAGE	ADJUST CONTROL NO.	COMMENTS
1	0.01	0.003	1(R341)	This control is located on top terminal board.
2	0.01	0.005	2	Recheck step 1 until both points are calibrated.
3	0.01	0.008	3	
4	0.01	0.01	4	Repeat steps 1, 2, 3, & 4
5	0.001	0.001	0.001 (R138)	Caution: Check PRESS TO BALANCE for minimum meter reading.
6	0.003	0.003	0.003 (R142)	0.001, 0.003, and 0.01 volt ranges should now be calibrated
7	0.03	0.01	0.03 (R144)	
8	0.03	0.015	5	Recheck step 7 until steps 7 and 8 are correct.
9	0.03	0.025	6	
10	0.03	0.03	7	Repeat steps 7 through 10.
11	0.1	0.03	0.1 (R145)	
12	0.1	0.05	8	
13	0.1	0.1	9	Recheck steps 11 and 12 until steps 11, 12 and 13 are correct.
14	0.3	0.1	0.3 (R146)	
15	0.3	0.3	10	Recheck step 14 until steps 14 and 15 are correct.
16	1.0	0.3	1.0 (R147)	
17	1.0	1.0	11	Recheck step 16 until steps 16 and 17 are correct.
18	3.0	1.0	3.0 (R148)	
19	3.0	3.0	12	Recheck step 18 until steps 18 and 19 are correct

TABLE 2

VOLTAGE MEASUREMENTS

PIN	1	2	3	4	5	6	7	8	9	
V101 BEC 525001	72V	0V	0.4V	-4.0V	-4.0V	88V	0V	0.6V	0V	DC
V301 12AX7	86V	0V	0.37V	-9.0V	-9.0V	70V	0V	0.37V	-4.0V	DC
	0.1V	0.075V	-	-	-	0.075V	0.0015V	-	-	AC
V302 7199	360V	32V	63V	-	0V	1.5V	0V			DC
	-	16.5V	-	5.7V	0V	-	0.1V	15V		AC
V303 12AT7	340V		2.9V			340V		4.9V	0V	DC
	-	-	-	6.3V	6.3V	-	-	-	0V	AC
V201 6X4							360V			DC
	325V		0V	6.3V		325V				AC
V202 OA2	150V	0V		0V	150V		0V			DC

CONDITIONS:

(1) DC Voltage Measurements with vacuum tube voltmeter (BEC 95A).

(2) AC Voltage Measurements with F.W. average responding vacuum tube voltmeter (Ballantine 314).

(3) 117V 60 cycles line input.

(4) All measurements to chassis.

(5) Input 10 mV at (300 Kc/s).

TABLE 3

D.C. RESISTANCE TO GROUND

PIN #	1	2	3	4	5	6	7	8	9
V101 BEC 525,001		22M	6.8K				2.2M	6.8K	
V301 12AX7		1M	1.2K				1M	2.2K	
V302 7199						1.2K	1M	20K	1M
V303 12AT7			3K-5K				50K-75K	4K-6K	
V201 6X4	1K					1K			
V202 OA2		0		0			0		

D.C. Resistance Measurements with Simpson 260 (polarity +, negative (blk) lead to ground).

TABLE 4

D.C. RESISTANCE TO CATHODE OF 6X4 RECTIFIER (PIN 7)

PIN #	1	2	3	4	5	6	7	8	9
V101 BEC 525,001	1M					500K			
V301 12AX7	200K					470K			
V302 7199		360K	820K						
V201 12AT7	550Ω					550Ω			
V202 OA2	8.0K				8.0K				

D.C. Resistance Measurements with Simpson 260 (polarity +, negative (blk) lead to 6X4 cathode).

TABLE OF REPLACEABLE PARTS

(for serial numbers above 9383)

Reference	Description				BEC Part No.
C101	Capacitor, Mylar	0.1	µF	200 V	230,116
C102	" Mylar	0.1	µF	200 V	230,116
C103	" Mylar	0.1	µF	200 V	230,116
C104	" Mylar	0.1	µF	200 V	230,116
C105	" Mylar	0.0033	µF	200 V	230,119
C106	" Mylar	0.022	µF	200 V	230,101
C107	" Mylar	0.0033	µF	200 V	230,119
C108	" Met. Paper	1.0	µF	200 V	230,104
C109	" Mylar	0.01	µF	200 V	234,027
#C110	" Ceramic	0.001	µF	500 V	224,121
C201	" Elect.	1000	µF	15 V	283,101
C202	" Elect.	3X20	µF	450 V	283,113
C301	" Mylar	0.01	µF	200 V	234,027
C302	" Mylar	0.022	µF	200 V	230,101
C303	" Mylar	0.068	µF	200 V	234,051
*C303	" Mylar	0.047	µF	200 V	234,002
C304	" Mylar	0.068	µF	200 V	234,051
*C304a	" Mylar	0.033	µF	200 V	234,025
C305	" Mylar	0.068	µF	200 V	234,051
*C305a	" Mylar	0.033	µF	200 V	234,025
C306	" Mylar	0.022	µF	200 V	230,101
C307	" Mylar	0.047	µF	400 V	234,047
*C307	" Mylar	0.068	µF	400 V	234,029
C308	" Elect.	20	µF	6 V	283,153
C309	" Mylar	0.01	µF	200 V	234,027
C310	" Mylar	0.22	µF	200 V	234,015
C311	" Elect.	4	µF	450 V	283,135
C312	" Elect.	200	µF	6 V	283,147
C313	" Met. Paper	1	µF	400 V	234,031
C314	" Elect.	4	µF	250 V	283,136
C315	" Mylar	0.022	µF	200 V	230,101
C316	" Elect.	10	µF	150 V	283,152
C317	" Mylar	0.022	µF	200 V	230,101
CR201	Rectifier, Silicon	Sarkes Tarzian			532,009
CR301	Diode	SG3113			530,040
CR302	"	SG3113			530,040
CR303	"	1N600			530,008
CR304	"	1N600			530,008

*For 50 cps models only

#In models with serial numbers 9765 and up.

Reference	Description					BEC Part No.	Alternate
R128	Resistor, Comp.	120	Ω	1/2	W	5%	301,065	
R129	" Comp.	1	M	1/2	W	5%	301,159	
R130	" Comp.	6.8	K	1/2	W	5%	315,012	
R131	" Comp.	1	K	1/4	W	10%	300,008	
R132	" Comp.	6.8	K	1/4	W	10%	300,013	
R133	" Comp.	2.2	M	1/2	W	5%	301,167	
R134	" Comp.	470	K	1/2	W	5%	301,151	
R135	" Comp.	2.2	K	1/2	W	5%	301,095	
R136	" Comp.	1	K	1/4	W	10%	300,008	
R137	" Met. Film	820	K	1	W	5%	315,022	
R138	" Var.	1	M	1/4	W	20%	311,183	
R139	" Comp.	820	K	1/2	W	5%	301,157	
R140	" Var.	25	K	2	W	10%	311,171	
R141	" Met. Film	82	K	1/2	W	5%	315,007	
R142	" Var.	200	K	1/4	W	20%	311,185	
R143	" Var. W.W.	10	K	1/2	W	10%	311,184	
R144	" Var. W.W.	10	K	1/2	W	10%	311,184	
R145	" Var. W.W.	10	K	1/2	W	10%	311,184	
R146	" Var. W.W.	10	K	1/2	W	10%	311,184	
R147	" Var. W.W.	10	K	1/2	W	10%	311,184	
R148	" Var. W.W.	10	K	1/2	W	10%	311,184	
R201	" Comp.	1	M	1	W	5%	302,128	
R202	" W.W.	2.4	Ω	1	W	5%	310,001	
R203	" W.W.	7.5	K	20	W	5%	312,107	
R204	" Comp.	680	Ω	1/2	W	5%	301,083	
R205	" Comp. **	1.1	K	1/2	W	5%	301,088	
R206	" Comp.	2	K	1/2	W	5%	301,094	
R301	" Comp.	1	M	1/2	W	5%	301,159	
R302	" Comp.	470	K	1/2	W	5%	301,151	
R303	" Comp.	2.2	K	1/2	W	5%	301,095	
R304	" Comp.	1	M	1/2	W	5%	301,159	
R305	" Comp.	200	K	1/2	W	5%	301,142	
***R306	" Dep. Car.	1.21	K	1/2	W	1%	306,253	326,258
R307	" Var.	15	K	2	W	20%	311,109	
R308	" Var.	10	K	2	W	20%	311,102	
***R309	" Dep. Car.	121	K	1/2	W	1%	306,488	326,508
R310	" Met. Film	200	K	1	W	5%	315,019	
R311	" Met. Film	200	K	1	W	5%	315,019	
***R312	" Dep. Car. **	5.9	K	1/2	W	1%	306,332	326,289
*** *R312	" Dep. Car. **	4.75	K	1/2	W	1%	306,321	326,285
R313	" Var.	25	K	2	W	20%	311,115	
R314	" Var.	10	K	2	W	20%	311,102	
R315	" Var.	10	K	2	W	20%	311,102	
R316	" Comp.	1	M	1/2	W	5%	301,159	
R317	" Comp.	1.8	K	1/2	W	5%	301,093	
R318	" Comp.	360	K	1/2	W	5%	301,148	

* 50 cps models only
** Factory selected
***At factory option, alternate part will be used.

	Reference	Description	BEC Part No.	Alter.
	CR305 Diode	SG3113	530,040	
	CR306 "	SG3113	530,040	
	CR307 "	1N914	530,058	
	CR308 "	1N914	530,058	
	CR309 "	Special	530,025	
	DS201 Lamp	GE #323 3 V	545,106	
	DS202 Lamp	GE #323 3 V	545,106	
	F201 Fuse	MDL-1.0 Amp.	545,510	
	F201 Fuse (230V models only)	MDL-0.5 Amp.	545,504	
	G101 Chopper	Special	540,113	
	L101 R. F. Choke	4.7 µH Nytronics WEE 4.7	400,113	
	L201 Choke	Stancor # C 1707	440,001	
	M101 Meter (for 91DA & 91DA-R)	Special 0-200 µA	554,187	
	M101 Meter (for 91DA-S5 & 91DA-R-S5)	Special 0-200 µA	554,186	
	R101 Resistor, Comp.	22 M 1/2 W 5%	301,191	
	R102 " Comp.	4.7 K 1/2 W 5%	301,103	
	R103 " Var. (Spec)	50 K 2 W 20%	311,168	
	R104 " Comp.	22 M 1/2 W 5%	301,191	
	R105 " Comp.	8.2 K 1/2 W 5%	301,109	
***	R106 " Dep. Car.	332 K 1/2 W 1%	306,541	326,5[illegible]
***	R107 " Dep. Car.	332 K 1/2 W 1%	306,541	326,5[illegible]
	R108 " Dep. Car.	5.36 M 1/2 W 1%	306,790	
	R109 " Dep. Car.	5.36 M 1/2 W 1%	306,790	
***	R110 " Dep. Car.	619 K 1/2 W 1%	306,573	326,573
***	R111 " Dep. Car.	619 K 1/2 W 1%	306,573	326,573
***	R112 " Dep. Car.	47.5 K 1/2 W 1%	306,440	326,404
***	R113 " Dep. Car.	47.5 K 1/2 W 1%	306,440	326,404
***	R114 " Dep. Car.	12.4 K 1/2 W 1%	306,371	326,377
***	R115 " Dep. Car.	12.4 K 1/2 W 1%	306,371	326,377
***	R116 " Dep. Car.	1.91 K 1/2 W 1%	306,273	326,264
***	R117 " Dep. Car.	1.91 K 1/2 W 1%	306,273	326,264
***	R118 " Dep. Car	1.15 K 1/4 W 1%	305,247	326,256
***	R119 " Dep. Car.	1.15 K 1/4 W 1%	305,247	326,256
	R120 " Comp.	100 K 1/2 W 5%	301,135	
	R121 " Comp.	100 K 1/2 W 5%	301,135	
	R122 " Comp.	15 K 1/2 W 5%	301,115	
	R123 " Comp.	390 K 1/2 W 5%	301,149	
	R124 " Comp.	100 Ω 1/2 W 5%	301,063	
	R125 " Comp.	2.2 K 1/2 W 5%	301,095	
	R126 " Comp.	6.8 K 1/4 W 10%	300,013	
	R127 " Comp.	22 M 1/2 W 5%	301,191	

*** At factory option, alternate part will be used.

Reference		Description					BEC Part No.	Alternate
R319	Resistor, Comp.	820	K	1/2	W	5%	301,157	
R320	" Comp.	1	M	1/2	W	5%	301,159	
R321	" Comp.	220	Ω	1/2	W	5%	301,071	
R322	" W.W.	20	K	20	W	5%	312,111	
R323	" Var.	15	K	2	W	20%	311,109	
R324	" Var.	25	K	2	W	20%	311,115	
R325	" Var.	10	K	2	W	20%	311,102	
R326	" Var.	10	K	2	W	20%	311,102	
R327	" Var.	10	K	2	W	20%	311,102	
R328	" Var.	10	K	2	W	20%	311,102	
R329	" Comp.	120	K	1/2	W	5%	301,137	
R330	" Comp.	33	K	1/2	W	5%	301,123	
***R331	" Dep. Car.	4.22	K	1/4	W	1%	305,314	326,281
***R332	" Dep. Car.	1.78	K	1/4	W	1%	305,269	326,262
***R333	" Dep. Car.	1.47	K	1/4	W	1%	305,259	326,260
***R334	" Dep. Car.	1.54	K	1/4	W	1%	305,262	326,261
***R335	" Dep. Car.	3.48	K	1/4	W	1%	305,304	326,273
R336	" Comp. **	8.2	M	1/2	W	5%	301,181	
R337	" Comp.	100	K	1/2	W	5%	301,135	
R338	" Comp.	2.7	K	1/2	W	5%	301,100	
R339	" Comp.	33	K	1/2	W	5%	301,097	
R340	" Comp.	1	M	1/2	W	5%	301,159	
R341	" Var.	2	M	1/10	W	10%	311,176	
R342	" Comp.	470	K	1/2	W	5%	301,151	
R343	" Comp.	470	K	1/2	W	5%	301,151	
R344	" Comp.	4.3	K	1/2	W	5%	301,102	
R345	" Comp. **	68	K	1/2	W	5%	301,131	
R346	" Comp.	3.9	K	1/2	W	5%	301,101	
R347	" Dep. Car.	2.49	M	1/2	W	1%	306,746	
R348	" Comp.	150	K	1/2	W	5%	301,139	
R349	" Comp.	22	M	1/2	W	5%	301,101	
S101	Switch	3 Pole, 8 Pos. Spec.					466,151	
S201	Switch	SPST Carling #110-63					465,105	
S301	Switch	5 Pole, 8 Pos. Spec.					466,140	
T201	Transformer	Power, Special					446,016	
T201	" (230V models only)	Power, Special					446,019	
V101	Electron Tube	12AX7, Special					525,001	
V201	Electron Tube	6X4					526,6X4	
V202	Electron Tube	OA2					526,OA2	
V301	Electron Tube	12AX7, Special					525,001	
V302	Electron Tube	7199					526,7199	
V303	Electron Tube	12AT7, Special					525,002	
VR301	Diode	1N1775A					530,046	
Q201	Transistor	2N554					528,003	
Q202	Transistor	2N404A or 2N1415					528,002	

** Factory selected

*** At factory option, alternate part will be used.

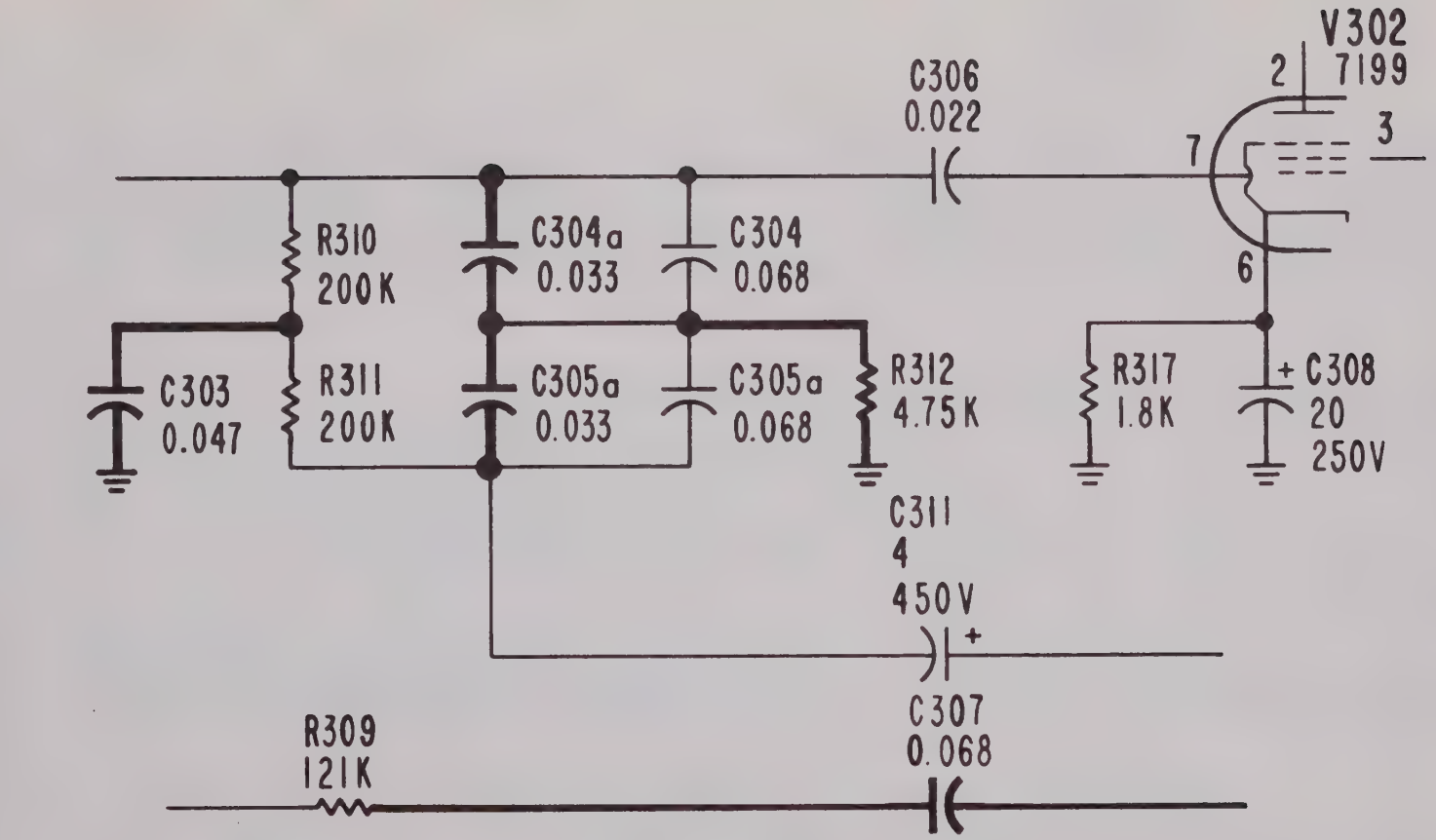


Figure 6. Circuit Modifications for 50 Cycle Models.

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE 1/2 WATT AND RESISTANCE VALUES ARE IN OHMS (K=10^3 AND M=10^6).
2. ALL CAPACITANCE VALUES ARE IN µF.
3. ⊘ DENOTES CALIBRATION CONTROL.
4. ⊛ DENOTES FACTORY SELECTED VALUE.
5. ON 230V AC MODELS, FUSE F201 IS 0.5A.
6. C110 IS INSTALLED IN MODELS WITH SERIAL NUMBERS 9765 AND UP.

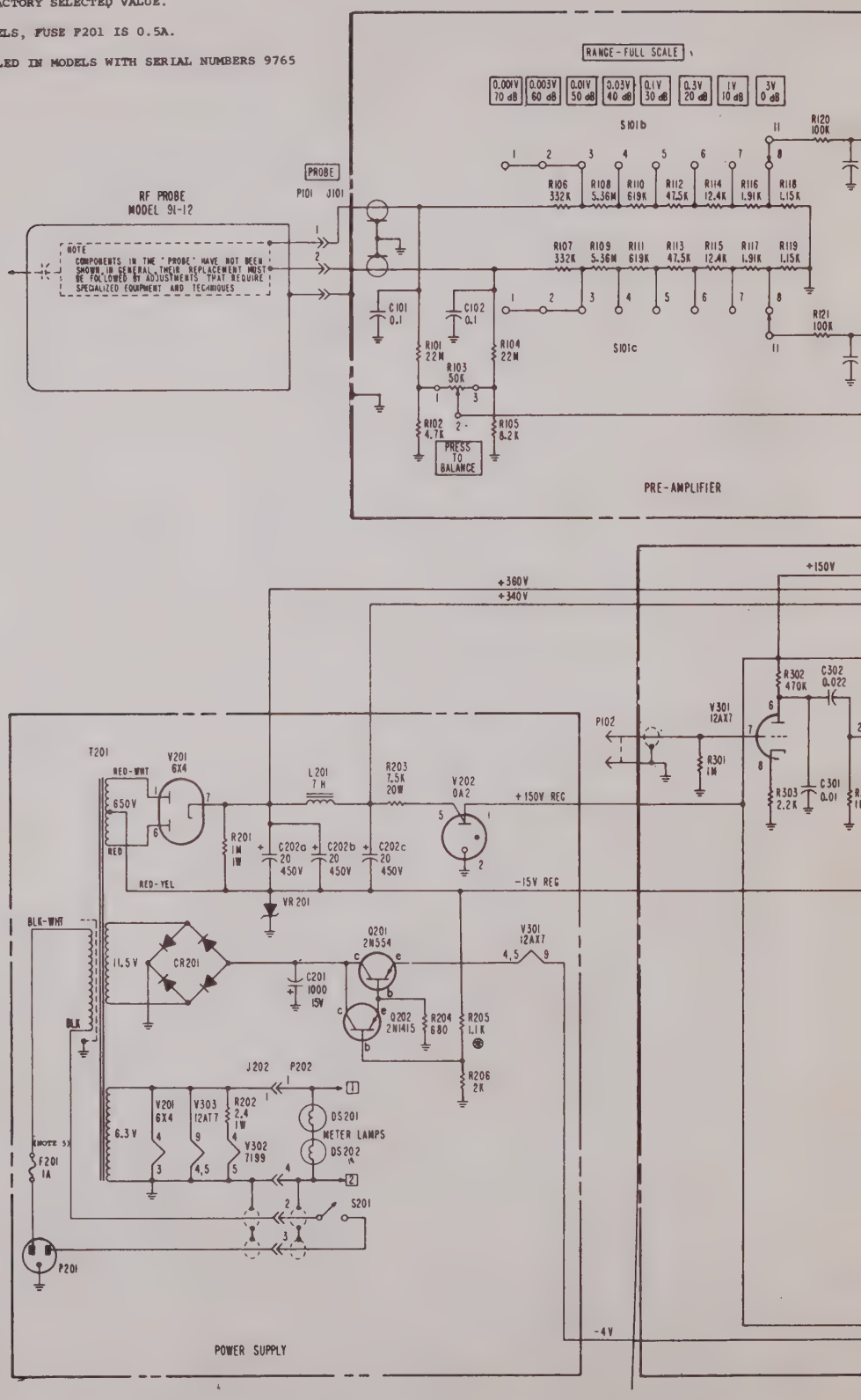
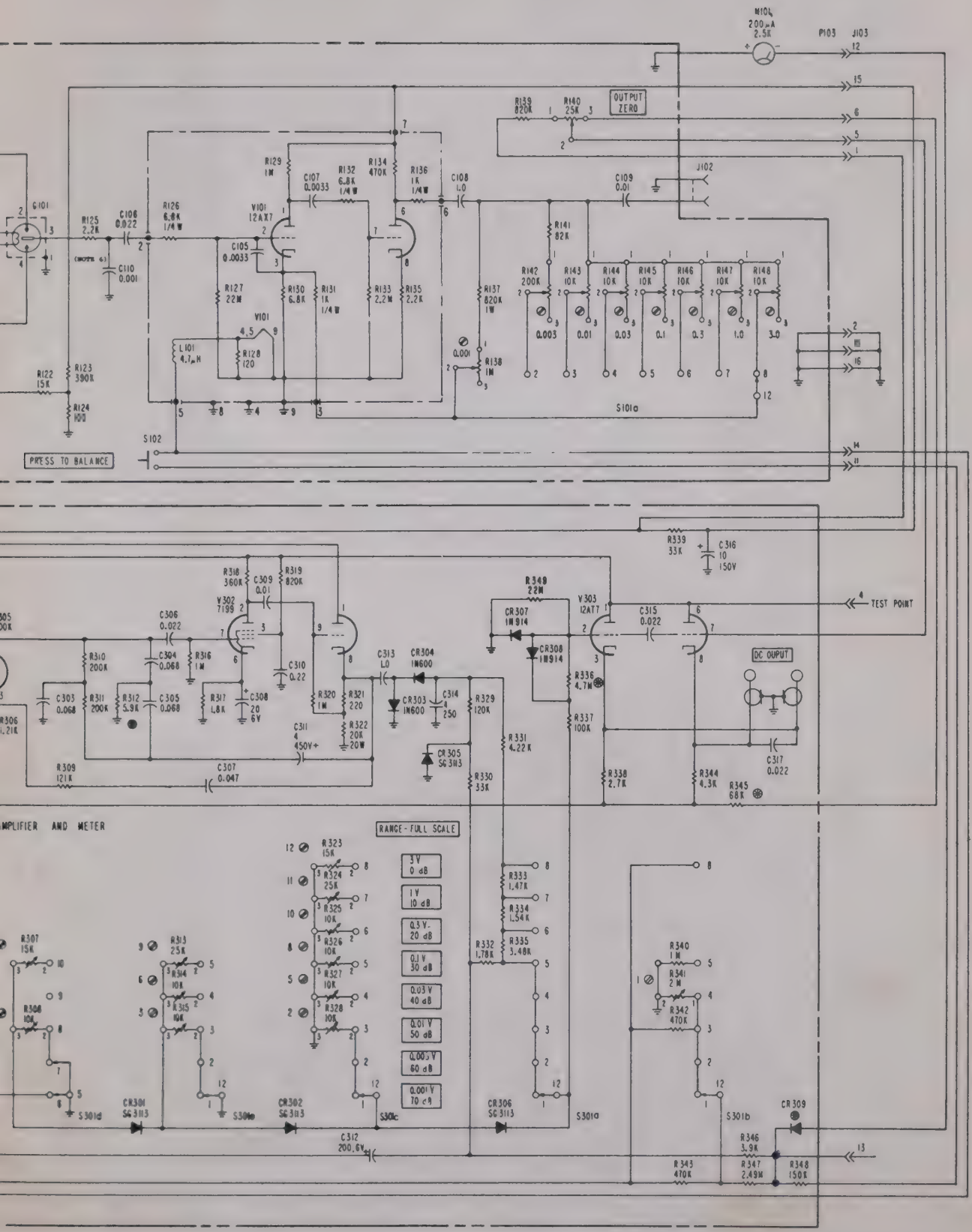


Figure 7. Schematic Diagram for Models with Serial No. 9384 or

Dwg



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Warranty

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to vacuum tubes that have given normal service, to sealed assemblies which have been opened, or to any item which has been repaired or altered without our authorization.

We will repair or, at our option, replace at no charge any of our products which are found to be defective under the terms of this warranty.

SHIPPING INSTRUCTIONS

If the instrument must be returned to the manufacturer, observe the applicable instructions below to ensure safe shipment.

a. Use the original packing material, if available, and pack in accordance with the reshipment instructions in this manual. The manufacturer will supply packing material at nominal cost, if desired. Contact the Sales Department, Boonton Electronics Corporation, Route 287 at Smith Road, Parsippany, N.J. 07054.

b. Alternately, wrap the instrument in heavy wrapping paper and seal the seams with gummed tape. Place the instrument in a fiberboard carton large enough to accommodate three inches of soft padding material. Seal well.